Operative Techniques in
Thoracic and
Cardiovascular Surgery

Surgical Repair of Post-Repair Pulmonary Vein Stenosis Using "Sutureless" Techniques

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Surgical interventions on the pulmonary veins pose technical challenges at the time of repair, primarily the creation of an unobstructed anastomosis between the pulmonary veins and the left atrium. Among survivors, the incidence of postoperative pulmonary vein stenosis remains a troubling clinical reality with significant potential for morbidity and mortality. Potential etiologies of late pulmonary vein stenosis may include direct trauma of the pulmonary veins at the time of repair, and turbulence arising from geometric distortion of the pulmonary vein anastomosis due to imperfections in surgical technique. For example, the divided edges of the pulmonary vein confluence at the time of repair of total anomalous pulmonary venous drainage may be have a complex morphology and, therefore, some distortion of these edges can be created at the time of primary anastomosis. Against this background, sutureless techniques have evolved as a method to treat patients with recurrent pulmonary vein stenosis occurring after repair of total anomalous pulmonary venous drainage.[1-3]

Although initially described for repair of postrepair pulmonary vein stenosis, the "sutureless" technique is readily adaptable to primary interventions on the pulmonary veins.[4] The technique can be used to simplify complex pulmonary vein anastomoses by exploiting the intellectual leap that direct anastomosis of the left atrium to the pulmonary veins is not necessary—and that anastomosis of the left atrium to the posterior pericardium is sufficient to obtain hemostasis. Employment of this technique eliminates the potential for surgically induced geometric distortion of the anastomosis arising from the suture line itself. The divided edges of the pulmonary veins are left to float freely in a hemostatic "neoatrium," which drains into the left atrium.

One of the compelling advantages of this technique is that it requires less technical precision than a direct anastomosis between the left atrium and the pulmonary veins—with important implications in terms of reproducibility and learning curve. Moreover this technique is easily adapted to a variety of surgical problems.

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Operative Technique

Repair of Bilateral Postsurgical Pulmonary Vein Stenosis with Atrio-Pericardial Anastomosis

Following a single lumen tracheal intubation and insertion of radial artery line and internal jugular venous line for monitoring, the patient is positioned on the table in a standard supine position. We routinely place a single towel roll under the shoulders oriented transversally to elevate the chest at the level of the body of the sternum and gently distend the neck. The chest is prepped and draped. The anterior mediastinum is accessed via a median sternotomy. Aortobicaval cardiopulmonary bypass is instituted and the body temperature is lowered to moderate or deep hypothermia. The dissection of the posterior pericardium is completed in both the left and the right posterior pericardial fossa to allow good mobilization of the heart. After positioning of the cross-clamp, cardiac arrest is obtained with cold antegrade blood cardioplegia.

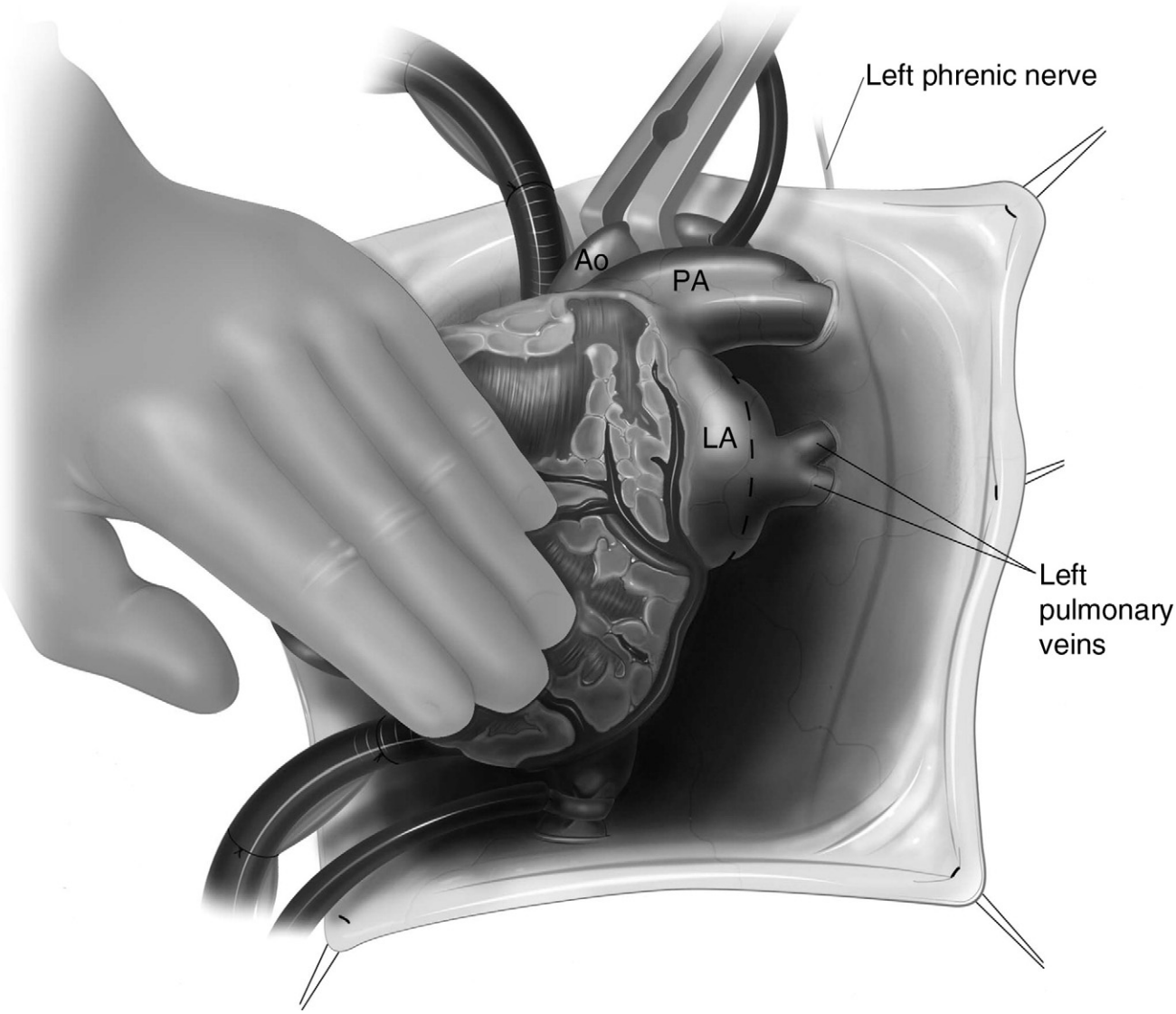

Figure 1 Surgical exposure of the left posterior pericardial fossa in a patient with post-repair pulmonary vein stenosis is obtained by retraction of the heart cephalad and to the right. The area of the posterior left atrium, including the previous anastomosis with the venous confluence, is exposed. An incision on the left atrial wall is created parallel to the atrioventricular groove in a superior-to-inferior direction around the left side of the previously created anastomosis between the left atrium and the pulmonary veins. Ao = aorta; LA = left atrium; PA = pulmonary artery.

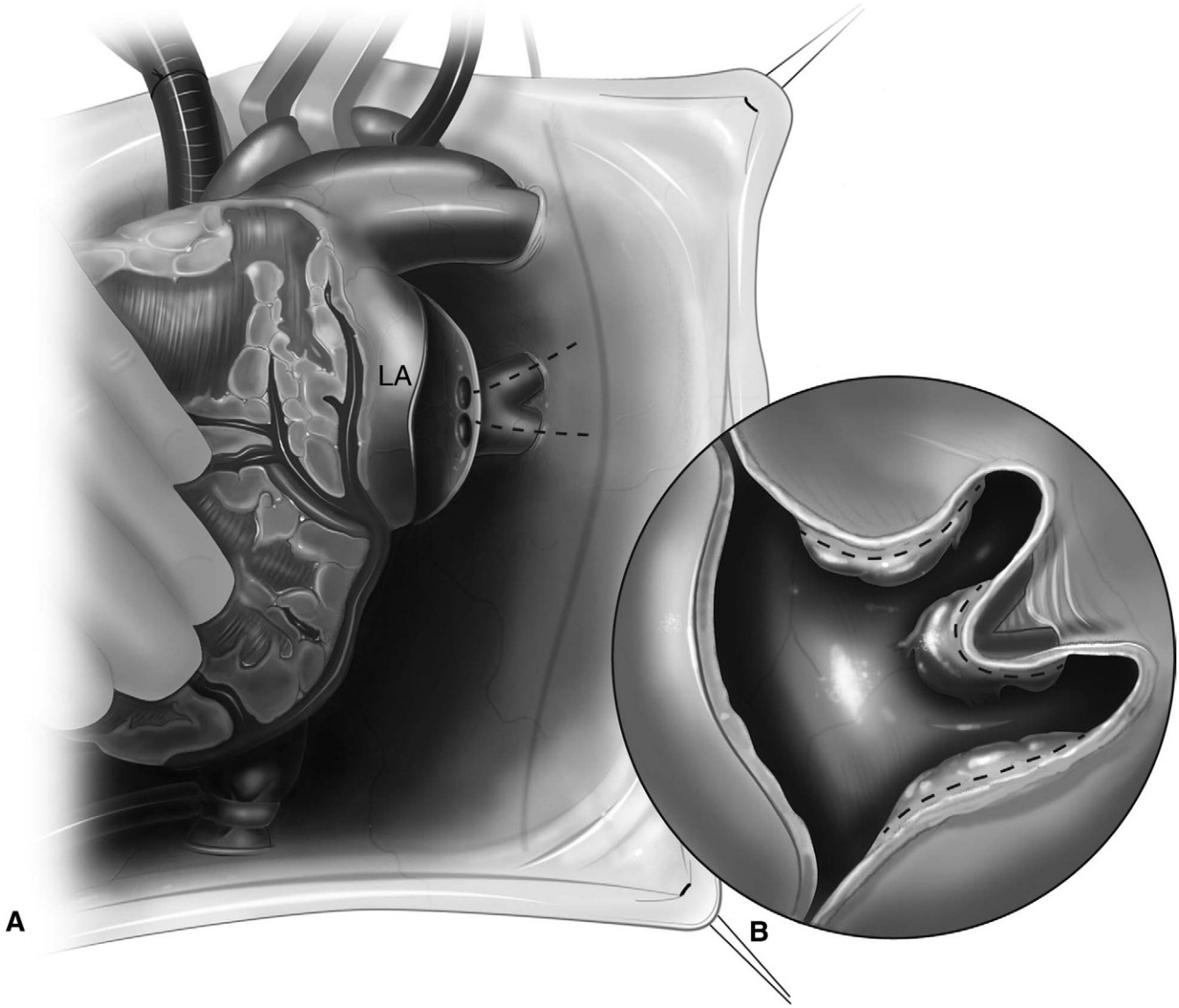

Figure 2 (A) The incision will expose the posterior wall of the left atrium and the stenotic orifice(s) of the pulmonary veins within the left atrium. Two additional incisions are then created through the anterior wall of the pulmonary veins and directed leftward and posteriorly toward the reflection of the posterior pericardium (dotted lines). Attention is paid to locate and avoid injury to the phrenic nerve. As a result of the incisions created, the lumen of the pulmonary veins will be exposed along the entire length of the veins and the stenotic areas are highlighted. (B) The diameter of the pulmonary veins should be much larger as the incision moves distally from the heart. The scar tissue at the level of the pulmonary venoatrial junction can be resected to improve the decompression of the pulmonary veins. LA = left atrium.

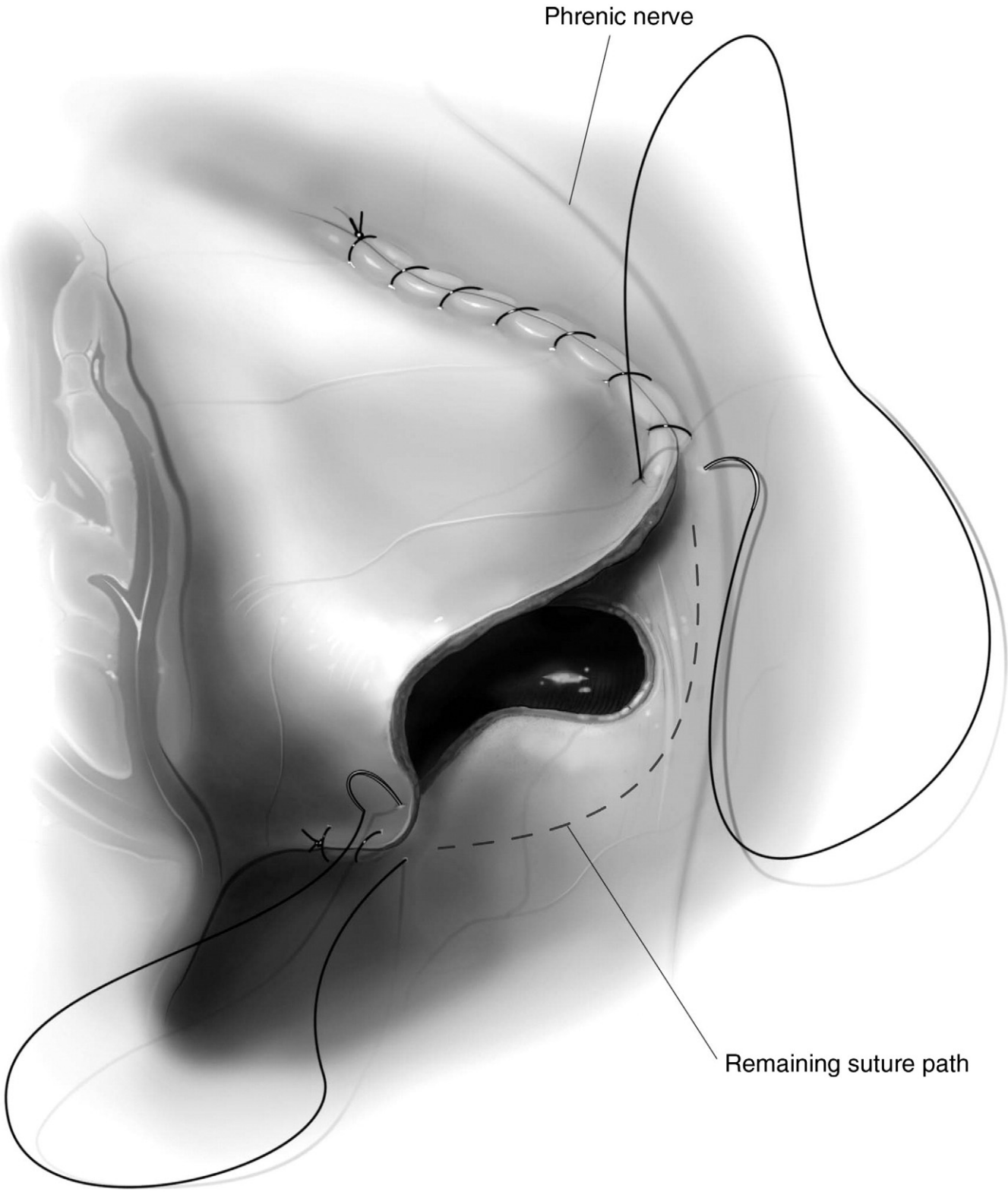

Figure 3 The free edge of the left atrium is now sewn to the pericardium surrounding the area of the veno-atrial junction, along the dotted line, starting at the top corner. We prefer to use a single layer of continuous 7/0 Prolene suture, holding the needle in a forehand direction. Attention is paid to avoid stitching the edge of the vein wall and the phrenic nerve, and gentle retraction should be used in this phase to avoid purse-string effect on the suture line. A second 7/0 Prolene stitch is used to complete the closure of the atriopericardial anastomosis from the inferior end of the atriotomy. The suture is finally tied in the midportion of the anastomosis after de-airing of the atrial cavity.

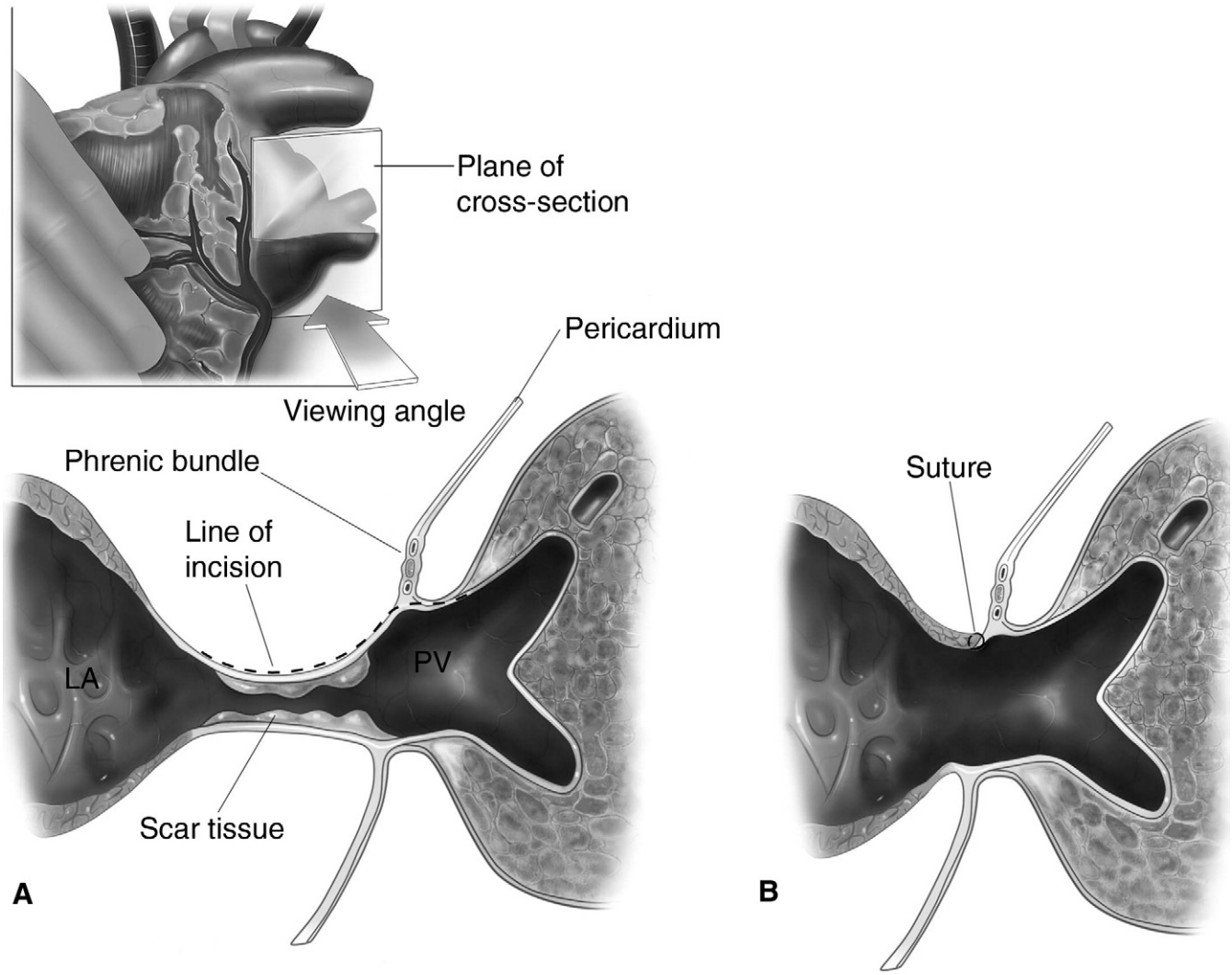

Figure 4 (A) In patients where the stenosis of the pulmonary veins progresses beyond the reflection of the posterior pericardium, we have adopted a more radical approach to venotomy. The incision along the anterior wall of the veins is prolonged beyond the pericardial reflection, passing below the line of the phrenic bundle and extending into the hilum of the left lung. Attention is made to preserve the continuity of the reflection of the pleura between its mediastinal and visceral layers, as bleeding into the pleural space is avoided by the continuity of this pleural reflection. (B) Repair is completed by resection of all intraluminal fibrotic material, and atriopericardial anastomosis is as described above.

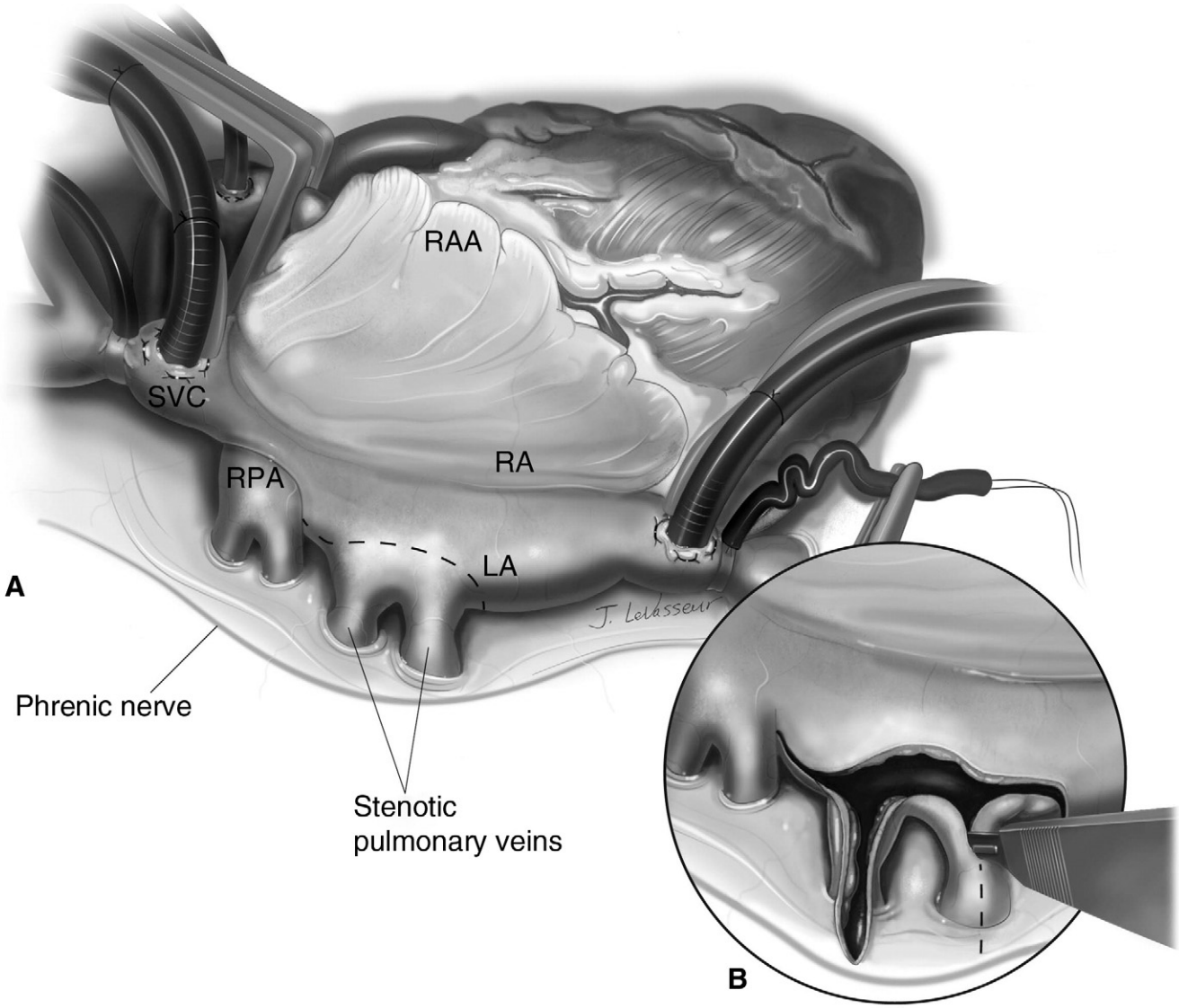

Figure 5 (A) Surgical exposure of the right posterior pericardial fossa is obtained by retraction of the heart to the left. The area below Waterston's groove is completely dissected out and exposed. The right pulmonary artery and the right-sided pulmonary veins are freed from adhesions. The left atrial cavity is accessed through an incision in the Waterston's groove. Superiorly the incision extends across the roof of the left atrium that extends under the superior vena cava. Inferiorly the incision progresses along the insertion of the right inferior pulmonary vein to avoid breaching the right atrium. The stenotic orifice of the right pulmonary veins within the left atrium is visualized. (B) The stenotic pulmonary veins are incised along their anterior surface toward the pericardial reflection just below the phrenic nerve. The incisions are carried on beyond the obstructed portion of the pulmonary veins. The scar tissue at the level of the venoatrial junction can be resected as needed. LA = left atrium; RA = right atrium; RAA = right atrial appendage; RPA = right pulmonary artery; SVC = superior vena cava.

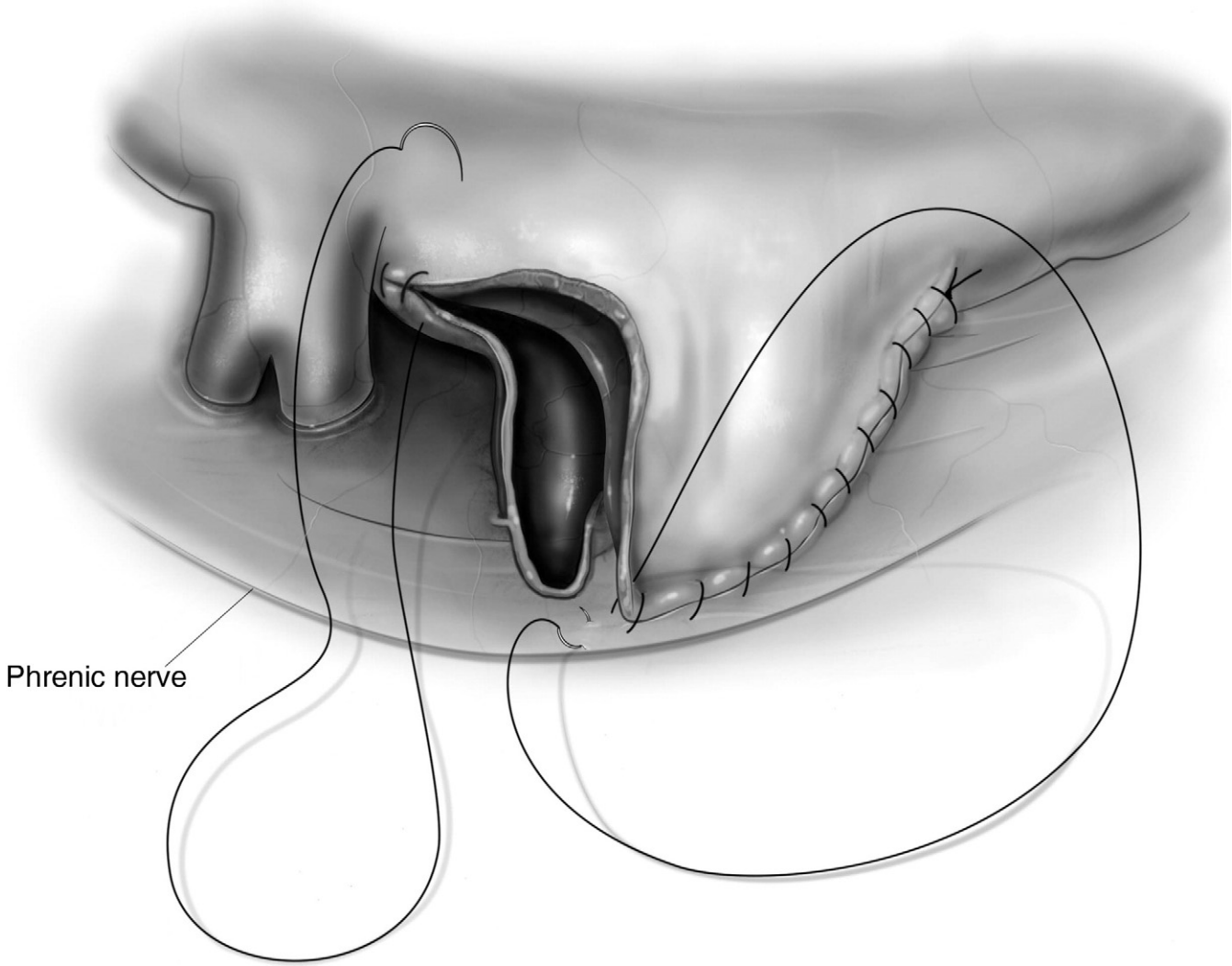

Figure 6 The free edge of the left atrium is now sewn to the pericardium surrounding the area of the venoatrial junction, along the dotted line, starting at the top corner. We prefer to use a single layer of continuous 7/0 Prolene suture, holding the needle in a forehand direction. Attention is paid to avoid stitching the edge of the vein wall and the phrenic nerve, and gentle retraction should be used in this phase to avoid purse-string effect on the suture line. A second 7/0 Prolene stitch is used to complete the closure of the atriopericardial anastomosis from the inferior end of the atriotomy. The suture is finally tied in the midportion of the anastomosis after de-airing of the atrial cavity. This completes the sutureless repair of postsurgical bilateral pulmonary vein stenosis.

Primary Repair of Total Anomalous Pulmonary Venous Connection with "Sutureless" Atriopericardial Anastomosis Technique

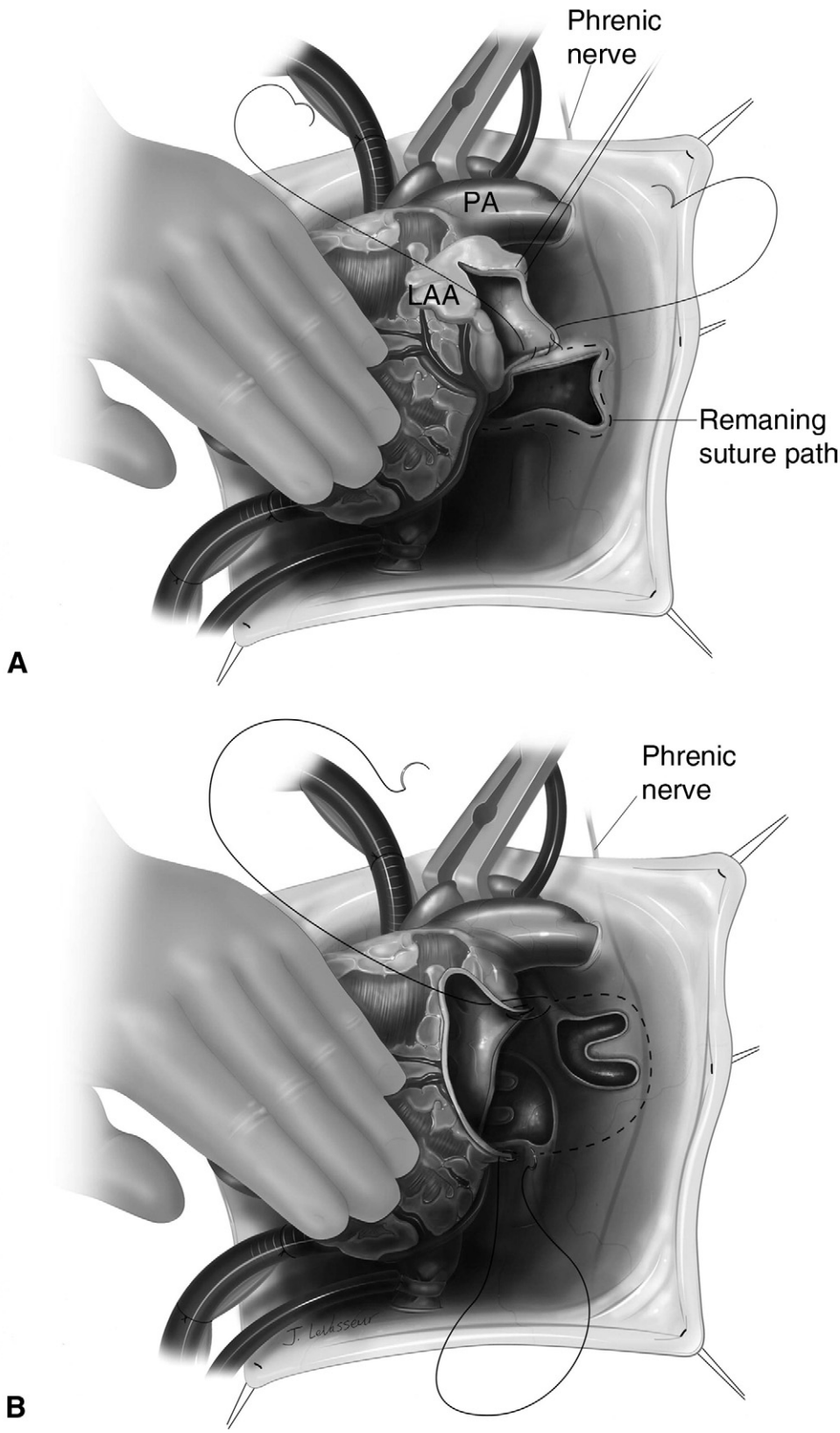

Figure 7 The sutureless technique can be used to perform primary repair of TAPVC. After standard institution of cardiopulmonary bypass, systemic cooling, and antegrade cardioplegic arrest, the heart is retracted cephalad and to the right. The veins behind the posterior pericardium are incised to create the largest possible opening in the pulmonary vein confluences. An incision is then opened in the left trial wall beginning at the base of the atrial appendage and extending parallel to the atrioventricular junction. The atrial wall is then anastomosed to the pericardial surface 5 to 10 mm away from the edge of the pulmonary venotomies, paying attention to avoid the left phrenic nerve and the pulmonary vein wall. A 7/0 Prolene stitch is used for the anastomosis beginning at the right corner of the atrial wall and extending in a circular single-layer running suture around the incised pulmonary vein confluence. We tend not to ligate the communicating vein. (B) The same technique can be used to repair mixed type TAPVC where complex pulmonary vein anatomy may make direct anastomosis between the atrium and the vein confluences difficult. In this case all confluences are opened with the widest venotomies possible and the left atrium is then sutured around the aggregated confluences as depicted. LAA = left atrial appendage; PA = pulmonary artery.

Repair of Bilateral Postsurgical Pulmonary Vein Stenosis with Pericardial Marsupialization Technique

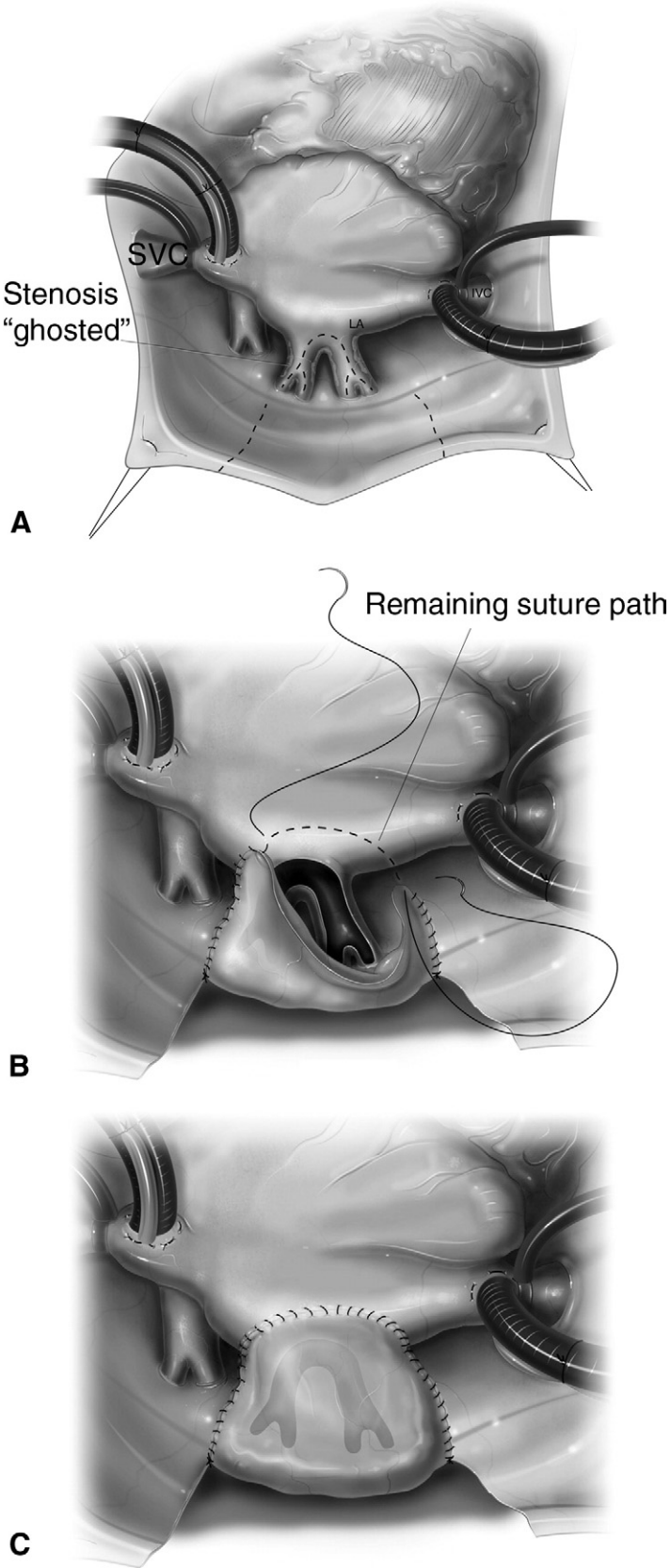

Figure 8 (A) Following institution of standard cardiopulmonary bypass, the heart is retracted to the left to expose the right pericardial fossa. Thorough dissection of the pulmonary veins and artery is completed and the right pericardial surface is cleaned from adhesions and scar tissue. The pulmonary veins are opened with an incision beginning in the wall of the left atrium just below Waterston's groove and extending rightward toward the hilum of the right lung. Attention is paid to locate and avoid injury to the right phrenic nerve. The incision is carried as far as possible into the hilar portion of the pulmonary vein to open the lumen to its largest diameter, and all scar tissue within the veins is removed. Two incisions are made from the edge of the right pericardium toward its reflection at the level of the phrenic nerve (dotted lines) to create a flap of the size of both pulmonary veins incision plus an additional 5 to 10 mm on each side. (B) The pericardial flap is then used to create a pouch on top of the venotomy by lowering it anteriorly onto the venoatrial junction. A single 7/0 Prolene running stitch is used to close the pouch beginning at the superior corner of the reflection and progressing anteriorly on the pericardial surface and then the atrial wall. A second stitch is used to complete the anastomosis beginning at the lower end and progressing anteriorly and cephalad. (C) Following gentle de-airing of the left-sided chambers, the stitches are tied together, thus completing the repair. The same technique can be used to repair the left-sided pulmonary veins. IVC = inferior vena cava; LA = left atrium; SVC = superior vena cava.

Conclusions

In our experience, the preparation of an atriopericardial anastomosis has proven to be less demanding a technique, as suturing the fragile vein wall is avoided. Therefore deep hypothermic circulatory arrest or periods of low flow can be avoided, at the surgeon's discretion. The technique is highly reproducible and can be taught to surgical trainees. We believe that the sutureless repair may prevent restenosis as a result of geometrical distortion as well as obstruction resulting from scarring of the anastomotic site. The postoperative recovery is largely comparable in our experience to children undergoing repair with the traditional techniques. However, we avoid high-pressure ventilation to prevent complications related to air embolism and we have adopted early institution of extra corporeal membrane oxygenation rather than prolonged cardiopulmonary resuscitation to treat postoperative cardiac arrest.

Since 1998 we have adopted the sutureless technique to treat recurrent pulmonary vein stenosis following repair of TAPVC. In a previously published series we were able to demonstrate a significant improvement in survival and reduction in need for further intervention in this difficult subgroup of patients[4] and our results have been confirmed by other authors adopting similar techniques.[5] Over the last decade we have extended the indications for the use of the sutureless repair to primary repair of simple TAPVC,[6] complex mixed type of TAPVC,[7] and primary pulmonary vein stenosis. In the series noted above, the sutureless repair was comparable or superior to the traditional techniques in preventing recurrence and need for reintervention.

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